

Detection and Classification of Baleen Whale Vocalizations from Autonomous Platforms

David M. Fratantoni
Autonomous Systems Laboratory
Physical Oceanography Department
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: (508) 289-2908 Fax: (508) 457-2181
Email: dfratantoni@whoi.edu

Mark F. Baumgartner
Biology Department
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: (508) 289-2678
Email: mbaumgartner@whoi.edu

Award Number: N00014-07-1-1004
<http://asl.whoi.edu>

LONG-TERM GOALS

Our long-range objective is to understand the oceanographic processes that influence the distribution of whales in the ocean. In support of this objective we seek to develop new techniques and technologies that enable us to relate the occurrence and movement of animals to physical, biological, and possibly anthropogenic forcing mechanisms over long time scales. This work will ultimately improve our ability to predict whale distribution and bolster efforts to mitigate human impacts on marine mammals.

OBJECTIVES

Our research has three specific objectives:

1. Develop a platform-independent modular acoustic package capable of automated detection and classification of whale vocalizations and suitable for use on a variety of autonomous platforms.
2. Characterize the efficacy of several automated detector algorithms using a rich set of collocated visual and acoustic measurements collected in 2006 and 2007.
3. Perform quantitative field trials to evaluate baleen whale detection performance in the context of other visual, acoustic, and environmental observations.

Report Documentation Page			Form Approved OMB No. 0704-0188		
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 30 SEP 2008		2. REPORT TYPE Annual		3. DATES COVERED 00-00-2008 to 00-00-2008	
4. TITLE AND SUBTITLE Detection And Classification Of Baleen Whale Vocalizations From Autonomous Platforms				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Woods Hole Oceanographic Institution,Physical Oceanography Department, Autonomous Systems Laboratory,Woods Hole,MA,02543				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES code 1 only					
14. ABSTRACT Our long-range objective is to understand the oceanographic processes that influence the distribution of whales in the ocean. In support of this objective we seek to develop new techniques and technologies that enable us to relate the occurrence and movement of animals to physical, biological, and possibly anthropogenic forcing mechanisms over long time scales. This work will ultimately improve our ability to predict whale distribution and bolster efforts to mitigate human impacts on marine mammals.					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 3	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

APPROACH

Almost all mitigation efforts rely on a comprehensive understanding of whale distribution to effectively separate human activities from baleen whales. This understanding is incomplete, however, and further research is needed to elucidate the environmental factors that govern baleen whale distribution.

Marine mammal distribution has traditionally been studied using visual surveys where human observers detect, identify, and count animals at the sea surface. These methods require adequate sighting conditions: daylight, good visibility, and low sea state. When conditions deteriorate, such as at night or in fog or heavy seas, detecting *any* marine mammals at the surface becomes difficult if not impossible. Conducting ship or aerial surveys for periods of weeks with many observers is both expensive and inefficient, since the observers search for marine mammals only during adequate sighting conditions and are idle during poor conditions. In contrast to visual surveys, passive acoustic detection can occur continuously (24 hours a day) in any weather conditions over weeks to months. However, most acoustic recorders used for marine mammal studies are moored and, except for very-low-frequency applications (e.g. blue whales), are limited to monitoring the area immediately surrounding the recorder.

Many of the limitations of both visual surveys and moored acoustic systems can be overcome by incorporating a passive acoustic monitoring capability on autonomous platforms. Ocean gliders and profiling drifters, in particular, have characteristics that are very well suited for passive acoustic monitoring: silent operation, long endurance (>1 month), and robust near-real-time satellite and/or radio communications. Gliders and profiling drifters offer a suite of oceanographic sensors that can be used in association with acoustic data to characterize marine mammal habitat. These sensors provide measurements that are comparable to or, in some cases, better than the measurements collected during modern, ship-based, marine mammal habitat studies.

WORK COMPLETED

During the past year, WHOI Student Fellow Sarah Mussoline, under the direction of Mark Baumgartner, isolated all baleen whale calls in 154 hours of acoustic data collected from an array of moored passive acoustic recorders deployed during 2006 and 2007. This dataset, along with 70 hours of collocated visual survey effort, will be used to validate detectors for right, sei, and humpback whales.

Fratantoni and Baumgartner attended an ONR workshop on the development of automated detectors for marine mammal vocalizations, Arlington, VA, June 19, 2008. At this workshop we presented the WHOI approach to developing automatic detectors for low-frequency baleen whale calls recorded from autonomous underwater vehicles.

RESULTS

Two significant papers were published in the past year (see below) including the first published account of the use of autonomous vehicles for the study of marine mammal ecology. This paper, appearing in a special volume of *Limnology and Oceanography*, summarizes new findings about sei whale vocalizations and feeding behavior inferred from glider operations in Great South Channel during May 2005.

A second paper, published in the Journal of the Acoustical Society of America, attributes a common low-frequency downsweep call to sei whales and describes an automatic detector for this call. This will be the first baleen whale detector implemented on the new WHOI D-MON instrument (see Related Projects, below). We will initially validate performance of this detector during D-MON bench testing using previously recorded/isolated/validated sei whale calls.

RELATED PROJECTS

In the past year this project has largely merged with a parallel WHOI effort to develop new broadband acoustic hardware and the accompanying software for automated detection and classification: “Development and Validation of a Mobile, Autonomous , Broadband Passive Acoustic Monitoring System for Marine Mammals” with PI’s Fratantoni, Baumgartner, and Johnson. Rather than developing a stand-alone low-frequency detector package as initially proposed, our baleen whale detector algorithms will be implemented in real-time on the D-MON, a low-power self-contained acoustic signal processing device developed at Woods Hole Oceanographic Institution (WHOI). This device has been created specifically for passive acoustic detection and so has the necessary broadband, low-noise signal acquisition capabilities. The device will be integrated in profiling floats and gliders to create a persistent detection capability. As detection algorithms mature, they will be ported to the D-MON for autonomous operation.

PUBLICATIONS

Baumgartner, M. F. and D. M. Fratantoni. 2008. Diel periodicity in both sei whale vocalization rates and the vertical migration of their copepod prey observed from ocean gliders. *Limnology and Oceanography* 53: 2197-2209.

Baumgartner, M. F., S. M. Van Parijs, F. W. Wenzel, C. J. Tremblay, H. C. Esch, and A. M. Warde. 2008. Low frequency vocalizations attributed to sei whales (*Balaenoptera borealis*). *Journal of the Acoustical Society of America* 124:1339-1349.